

***Using Twelve Lead ECG Diagnostic  
Capability in the Field***

**Executive Leadership (125)**

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## **ABSTRACT**

This research paper explored the use of 3-lead ECG cardiac monitoring equipment and the justification of upgrading to 12-lead capable ECG equipment.

The stated problem was that Central Yavapai Fire District did not have ECG monitoring equipment with 12-lead capabilities on paramedic ACLS response units.

The purpose of this research paper was to re-evaluate the existing ECG technology being used at CYFD and determine if there was justification for the cost of 12-lead ECG equipment upgrade. The method of research applied was evaluative and included a questionnaire to identify issues to be considered in implementation of new technology.

The research questions addressed were: 1). How would the delivery of EMS patient care be impacted by continuing 3-lead ECG cardiac monitoring? 2). How would the implementation of twelve-lead ECG monitoring equipment impact the delivery of CYFD EMS service? 3). Can the expanded diagnostic capabilities of twelve-lead ECG equipment justify the additional upgrade cost?

The procedures used to complete this research paper included a review of fire service and EMS service literature, interviews with health care providers and equipment vendors. In addition, the distribution of a survey questionnaire and review of local treatment protocols helped provide answers to the stated research questions.

The results of this research presented distinct and reasonable choices related to the eventual upgrading of CYFD's current ECG equipment with 12-lead capabilities.

The discussion section of this research paper provided a personal perspective on user-friendly issues associated with this portable, complex and powerful technology.

The proposed recommendations were based on the analysis and review of research information and survey data discovered through evaluative methodology. The decision to purchase monitor/defibrillators that have 12-Lead ECG up-grade capabilities was the best option for this medium sized, rural combination fire district.

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## INTRODUCTION

Visit any career or volunteer fire department in this country today and you will find that technology is rapidly changing the traditional way that firefighters respond to the challenges of their work. Technological advancements in every sector of the fire service from compressed air foam systems, helmet mounted imaging cameras, atmosphere detection devices and medical diagnostic equipment have reshaped the focus and complexity of the way firefighters do business. It is the responsibility of progressive emergency organization to utilize the best equipment, operational strategies and available information systems in providing the level of service that the public has come to expect. Most organizations recognize that the cost of providing emergency services continues to increase every budget year and have every expectation that this trend will continue in the future.

Funding priorities have forced fire departments to be more efficient, resourceful and accountable to those who ultimately bear the burden of paying for all the services rendered. Nowhere is this more apparent than in the area of safety, allied health and emergency medical services. The development and availability of lightweight portable diagnostic equipment has greatly enhanced the effectiveness of pre-hospital care providers. Innovations and improvements in equipment technology have had a significant impact, particularly in the rural areas served by EMS providers. Populations isolated from urban specialty medical facilities, are the people who stand to benefit most from new EMS technology and computerized equipment technology.

Central Yavapai Fire District (CYFD) is a combination fire department that serves a predominately rural population with approximately one hundred full-time employees and five manned fire stations. This service area is home to approximately thirty-five thousand residents distributed over one hundred and fifty square miles. Advanced Cardiac Life Support (ACLS) service is provided via paramedic engine companies that are manned with at least one paramedic firefighter and a minimum of two additional emergency medical technician's (EMT's). Paramedic personnel provide ACLS patient care via on-line medical control through the local hospital, Yavapai Regional Medical Center (YRMC). The state of Arizona issues medical certifications through the Department of Health Services and recognizes only three levels of certification, Emergency Medical Technician-Paramedic (EMT-P) Intermediate Emergency Medical Technician (IEMT) and Emergency Medical Technician-Basic (EMT-B). Private sector providers who respond at the request of fire district personnel provide ground ambulance and aeromedical patient transport capabilities. Central Yavapai Fire District does not have a state Certificate of Necessity (CON) required by the state of Arizona for patient transport licensure.

Advanced cardiac life support skills include, but are not limited to, ECG monitoring, external cardiac pacing, defibrillation and the administration of intravenous (IV) medications. Currently the CYFD utilizes *LifePack 10C* (3-lead ECG) *PhysioControl* cardiac monitor/defibrillators with external pacing capabilities. The 3-lead capability of these monitors has proven to be adequate for the assessment, treatment and cardiac monitoring of prehospital care medical and trauma patients. Development and

availability of 12-lead ECG technology has prompted the review of the cardiac monitoring capabilities currently being utilized at Central Yavapai Fire District.

**Problem Statement:** The cardiac monitoring equipment currently in use at Central Yavapai Fire District provide 3-lead ECG monitoring capabilities for cardiac and critically ill patients and do not have 12-lead ECG capabilities.

**Purpose Statement:** The purpose of this research paper was to reevaluate the existing ECG monitoring equipment in use at Central Yavapai Fire District and to determine if the replacement of this equipment with twelve-lead ECG capability would justify the replacement cost.

**Research Questions:** This research study employed the evaluative research methodology to review, evaluate and answer the following research questions:

1. How would the delivery of EMS patient care be impacted by continuing 3-lead ECG cardiac monitoring?
2. How would the implementation of twelve-lead ECG monitoring equipment impact the delivery of Central Yavapai Fire District's EMS service?
3. Can the expanded diagnostic capabilities of twelve-lead ECG equipment justify the additional upgrade cost?

This paper follows the applied research guideline requirements of the Executive Fire Officer Program was submitted as part of the Executive Leadership class requirement.

## BACKGROUND & SIGNIFICANCE

Central Yavapai Fire District has provided paramedic (ACLS) level EMS service to the residents of this north central Arizona fire district since August 1985. CYFD currently employs ninety-six full-time employees, twenty-three of who are certified at the paramedic level. The district's EMS program initially started the delivery of ACLS with ECG monitoring equipment (*Physio-Control LifePack 5*) that did not, at that time, include pacing capability and "*hands-free*" defibrillation. CYFD responded to 3749 alarms in the 1998-1999 fiscal year, 2546 of those were EMS related. A total of 1195 of those were classified as being ACLS and 1351 were considered BLS (see Appendix B, CYFD Profile, ALS responses).

One of the requirements for Advanced Cardiac Life Support units is the ability to monitor patient's electrocardiogram. In the field, this is usually accomplished through the use of a portable ECG monitor defibrillator that is capable of displaying an electronic "*view*" or "*picture*" of the ECG on a "*scope*" or digital display. In addition, most ECG monitors have the capability to display three different "*views*" or leads of the patient's cardiac activity. These are commonly referred to as Lead I, Lead II and Lead III, hence the name, three Lead ECG. When technology provides for the "*viewing*" of the electrical activity of the heart in nine additional "*views*" or "*perspectives*", this is commonly called or described as a 12-lead ECG. Up until the last eight to ten years, the use of 12-lead ECG as a diagnostic tool had been restricted to the hospital setting due, for the part, to the weight and size of the machines. New technology and computer

miniaturization has reduced the size and weight of this equipment while still making them affordable for prehospital use.

From the time period 1992 to 1994 all paramedic first line response units were upgraded to *PhysioControl LIFEPAK 10C* monitor defibrillators with external pacing and the safer “hands-free defibrillation” capability. That upgrade has proven to be adequate in providing paramedic personnel the emergency cardiac diagnostic tools needed to assess, treat and monitor critically ill patients. The performance of CYFD’s monitors (*PhysioControl/Medtronics*) has consistently been very good to excellent with only negligible “down time” due to minor repair or regular preventative maintenance. The fact that all Central Yavapai Fire District paramedic units use the same make/model of ECG monitor defibrillators has standardized and simplified the delivery of patient care: Three of the most obvious advantages to this standardization include: 1) Having one type of monitoring equipment makes it easier for providers who are required to work at as paramedic rovers. 2) The initial orientation and continuing education training is easier because all personnel use the same ECG monitoring equipment. 3) The purchase of batteries, patient cables, ECG paper and other associated parts and supplies is cost effective due to the standardized of equipment and bulk buying.

As part of the fire district’s budget preparation and purchasing account review process, the EMS Equipment Replacement Schedule is updated to reflect yearly and five-year projected needs. This review identified ECG monitor/defibrillators as one of the capital items that should be considered in a five year “phase-in” beginning in the



2000-2001 budget cycle (see Appendix B, EMS Equipment Replacement). Review of this replacement schedule prompted the re-evaluation of the ECG monitoring equipment currently being used in the field by the fire district. This review initially served as part of the background and analysis of the problems and issues researched in this paper. Sufficient evidence exists to justify the research and study of this problem based on past, present and future impact on Central Yavapai Fire District's ability to provide EMS service. The National Fire Academy's Executive Leadership program's emphasis on the development of decision-making skills provided the framework for the initial research procedures applied to this operational problem.

The EMS equipment replacement schedule required that a decision be made regarding the purchase of ECG replacement monitors defibrillators. The make and model selected would be a choice that the fire district would have to live with for several years to come. In addition, the following purchasing requisition criteria was considered and applied in the selection of EMS capital equipment purchases over \$10,000. While it is often difficult to successfully apply this selection criterion to every purchase, it will generally serve as a good guideline.

- Replacement equipment should be compatible with existing equipment in service.
- Equipment should have proven history of use in the field with realistic trial studies.
- Equipment must possess the functional capabilities of the equipment it replaces.
- The service life of replacement equipment should ensure a reasonable return for the initial purchase price or investment.

After a review of the available equipment specifications, features and replacement costs, a vendor's list was narrowed to two providers. The two ECG monitors that met the criteria were the ECG monitor/defibrillators manufactured by PhysioControl and Zoll Corporation. A feature by feature comparison of these products revealed that they both met the district's equipment specifications. Both vendors provided reliable testimonials from local EMS agencies that had used their equipment in the prehospital care setting. Phone inquiries to those agencies revealed general satisfaction in the products from all the users. The decision to purchase the PhysioControl LifePack 12 seemed to be the logical choice because it included all the specified features and was approximately two hundred dollars price difference with Zoll. It seemed that the choice would be easy to make and the product comparison provided all the necessary data for selection. The final consideration was the 3-lead verses the 12-lead ECG capability. While most monitor/defibrillators available today have 12-lead ECG capabilities, this technology increases the base price approximately six thousand dollars (\$6000) per unit. Everything else being the same, the question that needed to be considered was: *Is 12-lead ECG capability a patient care requirement or mandated by the local standard of care/patient care guidelines?* Mandating specific equipment requirements could significantly impact the fire district's EMS budget today and in the future.

Finding an answer to this question would require the careful review of past EMS performance and the available projections for future emergency response capabilities. Local EMS protocols and *base station* patient care guidelines specify only that *patients*

*who demonstrate signs and symptoms of cardiac compromise shall be monitored for the presence of lethal cardiac dysrhythmias.* In addition, the Arizona state Department of Health Services (Regulatory Agency) does not specify or mandate the use of 12-lead ECG monitoring of any patients. At present approximately eighteen percent of ALS prehospital care provider agencies in the state of Arizona utilize 12-lead ECG diagnostic monitoring and assessment capabilities. To help in making this equipment purchasing decision, a survey questionnaire was developed to solicit general information about 12-lead ECG usage in other fire department EMS organizations. The results and relevant survey responses are discussed in the Results section of this paper.

## **LITERATURE REVIEW**

A literature review was performed to identify existing research related to use of 12-lead ECG technology in the prehospital care. This search included journals, magazines, medical texts and an on-line review of Internet medicine web sites. Results from this research are summarized and included in the Results section of this paper.

The literature review was intended to help answer the stated research questions but was also to explore other related critical logistical equipment use issues. One of the issues the research hoped to resolve focused on the frequency of use for 12-lead ECG capability and particularly how often it was not used by prehospital care providers who have it available. The most current and relevant information was found primarily in medical and emergency services monthly journals. Recommendations developed from

this research are summarized and included in the Recommendations section of this paper.

In 1993 Steve Mercer, EMT-P wrote in his article, *12-Lead ECGs Ready to hit the streets*, for Emergency Magazine that, “Twelve-lead ECG’s have been used in the hospital and clinical setting for many years to assist in the diagnosis of cardiac related problems. Some factors that have prevented the movement into the prehospital setting have included cost, size, power supply and concerns that paramedics would be making diagnoses in the absence of a cardiologist. Today these concerns have been identified, studied and are being overcome.” (Mercer, 1993, p. 46). While it is true that the many of the technical and logistical issues have been addressed and for the most part corrected, one of the concerns centers on how diagnostic ECG information is utilized after it is collected, recorded and then electronically forwarded to the staff at the Emergency Room Department or base station. In their writing for JEMS magazine in April 1992, Mike Taigman and Syd Canan addressed other issues in an article for the Cardiology Practicum section entitled *The Push for 12-Lead ECG’s, ....* “Today when we ask how many people (prehospital care provider) use only Lead II in the care of their patients, more than 90 percent of people raise their hands. Even people who have taken (12-lead ECG) workshops, people who know and understand the benefits, sometimes revert to using Lead II. “It’s easier,” they say, or, “It’s what everybody doing.” Sadly, it seems that the possibility of being able to make better clinical decisions based on more accurate information has not been enough to create the

needed change in the majority of EMS providers to embrace 12-Lead technology” (Taigman & Canan, 1992, p. 65).

Clearly as early as 1992 some of the roadblocks to the utilization of 12-lead ECG in the field were already being recognized and the resistance to change was beginning to surface. In the same article Taigman & Canan conclude, “Resistance to change can be powerful...it is unfortunate that many people in the industry (EMS) have a tape that gets plugged in when they hear 12-lead ECG.....sadly it seems that the possibility to make better clinical decisions based on more accurate clinical information has not been enough leverage to create needed change in the majority of prehospital professionals”. (Taigman & Canan, p. 69). One of the early concerns that has plagued the widespread implementation was the issue of “interpretation” of 12-lead ECG tracings. “The use of computerized ECG interpretation software programs (in 12-lead ECG machines) should help decrease the concerns over field paramedics making diagnosis decisions in the absence of a cardiologist” (Mercer, 1993)

In Aufderheide’s et al. 1990 study of Milwaukee County paramedic system it was determined that it is feasible to apply a prehospital 12-lead ECG to most chest pain patients and that prehospital diagnostic accuracy is greatly improved compared to single lead telemetry. Grief (1998) discussed the advantages of having 12-lead diagnostic finding available during patient transport so that if the patient qualifies for thrombolytic drug therapy it can be administered without delay (Grief, 1998, p. 46-54).

Addressing the issue of delaying transport of critically ill patients to the receiving facilities, Foster & Mitchell write in their article *Racing the Clock* for JEMS, “In our own experience in Waynesboro, Penn., performing a field 12-lead ECG added only two and a half minutes to the average on-scene time for a chest pain patient” (D. Bruce Foster, D.O. & Brian K. Mitchell, EMT-P, 1996, p. 56). Some of the other time-consuming tasks that are a part of the general protocol for programs that prepare patients for the administration of thrombolytic (blood clot busters) agents include, “drawing blood samples, starting three I.V. lines and the administration of aspirin” (Foster & Mitchell).

## **PROCEDURES**

The research procedure used in this study began with a literature review of current articles related to 12-lead ECG prehospital technology and a search of the studies on file at the Learning Resource Center at the National Emergency Training Center. In addition, face-to-face telephone interviews were conducted with statewide EMS agency coordinators and field providers. Some of the research was historical in that the data from the literature review was used to determine how the current ECG technology has been applied in the past and how that same technology is changing today. A review of the survey questionnaires identified concerns about delays in the transportation of critically ill patients associated with use of 12-lead ECG monitoring technology and equipment in the field. The use of a supplemental questionnaire helped address and clarify concerns about field provider’s perceptions, base station support issues and field applications (see appendix A, Survey questionnaire).

Individuals selected for survey questionnaires and interviews met basic criteria (see survey questionnaire question number seven). The comment section in the survey questionnaire gave respondents the opportunity to give details of personal experiences and equipment use testimonials. Candid exchanges provided several unexpected results and a fresh perspective on what's really happening out in the field. The procedures followed in this research were specifically administered to provide information and data to support the purpose statement and help answer the research questions of this paper. It should be noted that the number of agencies and organizations surveyed was limited to the thirty-four agencies who currently utilize 12 Lead ECG technology within the state of Arizona. The survey questionnaires were not distributed to private provider ambulance companies although three ambulance companies did provide information informally via personal interviews. The most interesting or "telling" survey information was that collected in the comment section of the questionnaire. The review of the survey questionnaire responses led to a closer examination of the issues listed below:

- Does the use of 12-lead ECG delay the transportation of patients in the field
- Do providers perceive 12-Lead ECG technology of benefit to patient
- Do base station personnel support the use of 12-Lead ECG by providers
- Do providers feel that they have been adequately trained to use this technology
- Is the initial 12-lead ECG diagnosis given serious consideration by emergency room and receiving facility's staff

One of the limitations encountered in conducting this research survey was the limited number of agencies using the 12-Lead ECG technology and the experience they have had with this monitoring equipment and technology. Information compiled through direct telephone survey followed the twenty question format outlined in the survey questionnaire found in Appendix A of this paper. Thirty-four survey questionnaires were mailed directly to EMS coordinators of small to medium sized fire departments within the state of Arizona. Of the thirty-four surveys, twelve or thirty-five percent (35%) were returned by the November 15, 1999 deadline. Given that twelve surveys represented less than fifty percent (50%) of the agencies asked to participate in this research the decision was made to reach the agencies who had not responded directly through a phone interview. The researcher found that in general, providers were more comfortable with an informal telephone call than the “*fill-in-the-blanks & mail-back*” questionnaire survey. The personal feed-back from EMS providers who were interviewed revealed that in addition to being excited that someone was interested in their experiences and opinions, they were also interested in how others were using this technology. Finally, twenty-eight out of the thirty-four agencies (82%) surveyed provided responses that were used to supplement the research presented in this research paper.



## RESULTS

Review of related medical literature, survey results and personal interviews indicate that the successful and effective utilization of prehospital 12-lead technology often depends on a cooperative and complex system of professional networking. The data reviewed suggest that 12-lead ECG programs that hope to be successful must ensure all the mandatory program components are in place. The conflicts surrounding the relationships between EMS field providers and E. R. Department (base station) seem to stem from the fact that, E.R. physicians often rotate through the department or only work part-time. This limits the contact and exposure that providers have with the physicians and can compromise the professional interaction that builds trust and a close working relationship. Even in instances where there are positive provider/physician relationships, 12-Lead field ECG's are often not given serious consideration or ignored by the E.R. physicians or the cardiologist who ultimately are responsible for the patient upon admission to the hospital. Providers who were interviewed attribute this to the fact that some cardiologist are only comfortable or have confidence in the 12-lead ECG tests that they order and are administered in the hospital. Providers agreed that this problem was primarily a training, orientation and education issue that needed to be addressed within the hospital and fire agencies by administrative level personnel.

Consideration must be given to providers who complain, "*there are already to many other wires and tubes attached to the patient making assess to the patient even more difficult!*" Indeed, when you considers that most patients will have a least an I.V. line, pulse oximeter cord, oxygen supply tubing, blood pressure cuff and ECG cables

connected to the upper torso, the complaint has some merit. When you add the fact that patients are then squeezed into the confine space of an ambulance or a medical helicopter, this access issue should not be trivialized. The *patient access issue* becomes exacerbated when a patient arrests and requires chest compressions or defibrillation while being transported. It would be easy to conclude that, in spite of their appeal, complex and advanced technologies have the tendency to “get in its own way!”

Although every ECG monitor vendor will swear that setting up and using 12-Lead technology doesn’t take anymore time than a 3-Lead, the fact is, interviews conducted for this research paper contradict those assumptions. In fact, the most common complaint about the use 12-Lead ECG monitors was that, “*it takes too long to connect or “set-up” the patient and that contributes to the delays associated with moving and handling the patient!*”

The research, analysis and procedures methodology utilized in this paper provided the following answers to the research questions presented in the introduction of this research paper. These answers were formulated after thorough consideration of all the data and information collected and reviewed.

**1. How would the delivery of EMS patient care be impacted by the continuing 3-lead ECG cardiac monitoring?**

There would be no negative impact on the delivery of EMS patient care in the fire district with the continued use of 3-Lead capable monitors/defibrillators. Currently there are no studies that compare the survivability of cardiac patients who are monitored by 3-lead as opposed to 12-lead ECG equipment. The continued use of 3-lead ECG's is in full compliance with pre-hospital care protocols and the local standard of cardiac care.

**2. How would the implementation of twelve-lead ECG monitoring equipment impact the delivery of Central Yavapai Fire District's EMS service?**

While it is difficult to predict the impact of this change within the fire district, upgrading diagnostic capabilities of pre-hospital care equipment is generally perceived as being a positive change. The research survey clearly demonstrated that the upgrade of equipment alone may not necessarily provide all the answer or impetus that is required to improve delivery of service. Field pre-hospital care providers must to recognize that there are important logistical, and often time-consuming, tasks that go along with "setting-up" patients for the new 12-Lead ECG technology. E.R. Department staff and physicians have to willingly "*come on board*" and recognize that the only way new field technology will benefit the patient is when it is administered in a supportive, cooperative and synchronized team approach.

**3. Can the expanded diagnostic capabilities of twelve-lead ECG equipment justify the additional upgrade costs?**

Research data and clinical studies indicate that when all the important elements of the system work together and the medical community fully appreciates the over-all benefit of this technology, the answer is yes, the cost can be justified. Acquisition or use of new technology alone can not guarantee that there will be a direct benefit or even that patient outcomes will be improved. Successful implementation of EMS technology must include a comprehensive program of training, system support and the common desire to make the program work.

## DISCUSSION

This research began with the intention of studying the stated research questions and developing a plan or strategy for implementing a phase-in purchase plan for ECG equipment for the fire district. The initial research and literature review revealed that this issue was not widely studied or written about. It was not until the responses and results from the survey questionnaire were collected by this researcher that it became obvious that it was not just an issue of, “the agency that has the newest and best ECG diagnostic equipment is able to offer the best service!” Indeed, like many other services in medicine, having the latest equipment is only part of the solution. The idea that this new technology could be introduced and implemented as easily as setting up a new desk-top computer system remains a figment in the imagination of the salesman who guarantees that “*many more lives will be saved.*” In some cases, the only ones who stand to gain are the salesman themselves. What is becoming increasingly clear is that

unless a coordinated and cooperative medical care system is already in place, the implementation of truly effective 12-lead monitoring programs is mediocre at best.

The preconceived notions that EMS providers have about a product or piece of equipment is critically important to the success or failure of its implementation. Survey interviews revealed that often field providers resented the fact that their judgement or patient assessments was dismissed by health care workers who are not part of the network and don't know how the system is supposed to work. Others expressed their frustration that while they were aware of the benefits of 12-Lead ECG's, they felt had little or no support in making the technology work. One paramedic lamented during a telephone interview, "No one outside of field providers can appreciate the logistical nightmare associated with trying to make complicated technology do what its designed to do in the worst possible situations" Other providers voiced their concern that once a patient is connected to a monitor some paramedics seem to develop "*tunnel vision*" and may unintentionally ignore other important aspects of patient care, treatment and continued assessment while trying to concentrate on the 12-lead ECG.

The observation of this researcher is that perhaps in many aspects the complexity of all the new technology may be running way ahead of the tasks they are designed to accomplish. We have to ask ourselves, "*What is it we are trying to accomplish with or medical intervention?*" For right now perhaps we're trying to do too much. Or at the very least we may be trying to do so many things at the same time that we aren't doing an adequate job of any of the tasks. Not one provider interviewed in this study believed

that 12-Lead ECG technology should be abandoned as a pre-hospital care diagnostic tool. Most believed that the technology needs refinements and practical engineering that will provide a more “*user friendly*” interface. Finally, it was apparent in some interviews that many providers felt obligated to use the technology because it was purchased, installed and that their employers wanted to make sure that the public was getting their monies worth.

In summary, It will take improved technology, better system/agency cooperation and a commitment from all the providers to make it work. Firefighter should never lose sight of the primary mission of pre-hospital care providers: Rapid response, patient stabilization and safe and expedient patient transport to the appropriate medical facility.

## **RECOMMENDATION**

The proposed recommendations in this research paper are submitted in response to problem statement and attempt to provide answers or solutions to the stated research questions. The recommendations offered in this research paper are a product of a comprehensive review of the related information and data. Additionally the proposed recommendations flow logically from the specific research results and are supported by the included data collection.

**Proposed Recommendations:**

- Central Yavapai Fire District should purchase PhysioControl LIFEPAK 12 monitor defibrillators with 3-lead ECG capabilities as the replacement for the current LIFEPAK 10C monitors. (approximate cost \$10,260.00 with hard case & cables)
- The LIFEPAK 12 monitor defibrillators should have the capability to be up-graded to utilize 12-lead ECG technology as needed. This after-market up-grade is estimated to cost approximately six thousand one hundred dollars (\$6100.00) and would be installed by PhysioControl technicians.

**Recommendation Summary:**

The purchase of LIFEPAK 12 cardiac monitor defibrillators will more than satisfy the monitoring requirements of critically ill patients but more importantly, will easily allow the upgrade to 12 lead ECG capability by installation of internal circuitry. This option provides the flexibility to limit the initial cost of equipment purchase and maintain the option to upgrade in the future.

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*Appendices Not Included. Please visit the Learning Resource Center on the Web at <http://www.lrc.fema.gov/> to learn how to obtain this report in its entirety through Interlibrary Loan.*